



Method for the Liquid Cleaning of Objects

The invention relates to a method for the liquid cleaning of objects.

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In practice, cleaning objectives are encountered at very different locations, be it for the liquid cleaning of objects of metal, glass, ceramic, plastic or composite materials, to remove contaminations for the reuse of the objects in a clean state, for example in hospitals or domestic use, be it for the cleaning of objects within manufacturing processes in which the processing technique such as lacquering, soldering, welding, etc., requires clean surfaces, or be it for the cleaning of textiles, just to name a few examples. In this connection, very different contaminations must be removed, for example inorganic dirt such as pigments or dirt containing ionic salts that are easily removed with water, organic dirt in the form of residues from charging, lubrication, lapping and polishing paste, soldering paste, adhesives, etc., as well as various combinations of the types of dirt mentioned by way of example.

For respective types of dirt various solvents are provided that dissolve the respective dirt particularly well, whereby such solvents are not only expensive, but frequently also have a poor compatibility with the environment, so that one must use them as sparingly as possible.

DE 199 08 434 A1 discloses a method for the liquid cleaning of objects according to which the objects that are to be cleaned are brought into intense contact with a cleaning liquid that has an organic solvent having good solubility characteristics for the dirt that is to be removed, and is present in the form of an emulsion of the type solvent in water. With such an aqueous emulsion, despite relatively small concentrations of the solvent organic dirt, as well as inorganic dirt due to the water content, can be effectively removed. Removed dirt is to be deposited on the surface of the cleaning liquid from where it is removed, so that the cleaning liquid, i.e. the solvent contained therein, need be only slightly topped off.

The object of the present invention is to provide a method for the liquid cleaning of objects with which excellent cleaning effects are achieved and with which the quantity of required solvent or solvents or organic components is further reduced.

This object is realized with the features of the main claim.

The invention utilizes the recognition known from the aforementioned DE 199 08 434 A1 that cleaning liquids having at least two components, which are adapted to the respective contamination, clean

particularly efficiently if the two components, under certain first conditions, for example under certain pressure and temperature conditions, form a solubility gap in the concentrations that are present.

5 For the purposes of definition, in the following "mixture" means a system comprising two or more types of molecules, the chemical and physical characteristics of which are spatially constant (homogeneous system). A solution is a mixture with which one material or one type of molecule is present in excess. Two liquids form a solubility gap if they
10 cannot be mixed together without limitation; one then obtains two liquid phases in which the components of the liquid are present in a varying composition, for example, the one component extensively in the one phase and the other component extensively in the other phase. A solubility gap can be observed in that the clear liquid becomes turbid
15 with a change in temperature, i.e. forms an emulsion, that is an indication of the phase separation. However, the turbidity or emulsion is not a necessary indication for a solubility gap; there are so-called micro emulsions in which the two phases are finely distributed such that the liquid continues to be optically clear.

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Due to phenomena that up to now are not fully understood, in general a liquid that is composed of two components and is in the state of a

solubility gap has a better cleaning capacity than do the two individual components if they are used in a pure state or in a highly concentrated state one after the other. Perhaps the excellent cleaning effect of liquids that are present in a solubility gap is brought about by interaction at the interfaces between the two phases, and possibly additionally by mechanical effects due to the droplets that are frequently held in distinct movement via ultrasound or a stirring mechanism. The use of the liquid in the state of the solubility gap thus enables an advantageous cleaning not only with regard to its cleaning effect but also with regard to the duration and with regard to the quantities of individual components that are required.

So that the cleaning liquid can remain in use as long as possible, it must be freed from the contaminations that it has received. Pursuant to the invention, this takes place in that the cleaning liquid is brought out of the state of the solubility gap into the state of a true mixture, i.e. a homogeneous state. From this homogeneous liquid the contaminations can be removed, depending on the nature thereof, via a filter (especially inorganic pigment-containing contaminations), or in that the contaminations, as a consequence of their densities that are different from the liquid, accumulate at the base or on the surface of the liquid, from where they are withdrawn (especially fatty

contaminations). If a filtration or a separation of the liquid is, in contrast, to be effected in the state of the solubility gap, in so doing also a large percentage of at least that component is separated off that ties up or captures a respective contamination or binds it to its contact surface.

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On the whole, as a result of the planned conversion of the cleaning liquid on the one hand into the state of the solubility gap for the cleaning, and on the other hand into the state of the true mixture for the separation of the contaminations, an efficient method is provided for the liquid cleaning of objects, which method, with an extensive ability to recycle the cleaning liquid (separation of contaminations), enables an effective cleaning of very different types of objects. It is to be understood that the composition of the cleaning liquid is adapted to the respective cleaning problem, whereby it is merely mandatory to select such components that under first designated conditions form a solubility gap, and under second designated conditions mix with one another.

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With the features of claim 2 there is achieved the advantage that not only inorganic but also organic dirt can be dissolved, whereby the organic component can frequently be present in a relatively low

concentration and yet cleans as if it were present in a higher concentration.

5 A very good cleaning effect for a wide variety of types of contamination is achieved with the features of claim 3, whereby numerous organic components that are provided with molecules having lipophilic and hydrophilic groups form a solubility gap with water.

10 With the features of claim 4, a cleaning method is provided according to which the cleaning liquid comprises predominantly water.

15 The method of the present invention can be carried out in a particularly straightforward manner if the state of the solubility gap changes over into the state of the mixture by merely altering the temperature. Other possibilities for converting the two states into one another comprise a change in pressure, a particularly intensive agitation, e.g. by means of ultrasound, by introduced contaminations that lead to a shifting of an equilibrium or to an unstable state suddenly changing over into a stable one, etc.

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The function of the described apparatus, which on the whole operates at atmospheric pressure, is as follows:

5 The previously described cleaning liquid is optically clear at room temperature, i.e. the organic component forms a true mixture with the water. If the cleaning liquid is heated to 40°, a turbidity occurs, which indicates that the solubility of the organic component in the water is exceeded and a two-phase system forms, with organic-rich droplets in a continuous aqueous phase. The cleaning tank 2 is held at a
10 temperature of 40°, and the cleaning liquid disposed therein is intensely swirled with the agitation device 16. The transport mechanism 20 is lowered into the cleaning tank 2, so that the objects that are to be cleaned come into intensive contact with the cleaning liquid, which is in the state of the solubility gap. In so doing, the
15 cleaning liquid is continuously pumped off into the separation tank 8 via the pump 4, with the separation tank being held at a temperature of only 20°, so that the contaminated cleaning liquid is present at that location in the state of the true mixture. Organic dirt, which is specifically lighter than the liquid, is deposited on the surface and can
20 be removed with a rake 22 or some other device. Specifically heavier dirt is deposited at the base of the separation tank 8, where it can be withdrawn via a non-illustrated known device.

From the separation tank 8, in which the cleaning liquid, which is present in the state of the true mixture, has a minimal movement, the cleaning liquid is transferred via the overflow 9 into the collection tank 10, which is also held at 20°, so that the cleaning liquid remains in the state of the mixture. From the collection tank 10, the cleaning liquid is pumped off via the pump 12 and flows through a filter device 19 in which the inorganic and/or particulate dirt is removed by filtration. The cleaning liquid that is cleaned of contamination in this manner passes back into the cleaning tank 2, where it again comes into contact with the objects that are to be cleaned. The cleaning process continues until the objects are freed of all contaminations, whereupon the transport mechanism 20 is removed from the cleaning tank 2.

It is to be understood that the described apparatus can be modified in many ways. For example, the transport mechanism 20 can subsequently also be moved into a rinsing container having hot water and/or into a drying tank. Furthermore, the cleaning liquid does not necessarily have to be continuously pumped or circulated, rather, the removal of the contaminations taken up by the liquid can occur in a batch-wise manner.

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water at room temperature, and then the concentration up to which water can be added and be soluble with the organic component. In the first example, glycol ether, the solubility gap at room temperature is thus between 5% and 82% glycol ether in 95% or 18% water respectively. The subsequent information (first example): MPC (Multi Phase Cleaning) at 5% starting at 29° C indicates respectively the concentration of the organic component with which one advantageously operates with the respective liquid, and the temperature above which a good cleaning effect is achieved due to the stable solubility gap. For the complete mixing or for the separation of the contaminations, the liquid is respectively advantageously cooled off to room temperature. It is to be understood that one advantageously works with concentrations that are slightly, e.g. 0.1 to 0.2 %, below the concentration at which the solubility gap occurs at room temperature.

Glycol Ether:

- Propyleneglycolmonobutylether PnB

Water Solubility 5%

Water in PnB 18%

MPC at 5% starting at 29° C

- Dipropyleneglycolmono n-butylether DPnB

Water Solubility 4%

Water in DPnB 14%

MPC at 1% starting at 23°C

- Tripropyleneglycolmono n-butylether TPnB

5 Water Solubility 3%

Water in TPnB 8%

MPC at 3% starting at 23° C

- Tripropyleneglycolmonopropylether TPnP

10 Water Solubility 5%

Water in TPnP 12%

MPC at 5% starting at 45° C

- Propyleneglycolphenylether PPH

15 Water Solubility 1%

Water in PPH 6%

MPC at 1% starting at 23° C

Ester / Acetate

20 - Propyleneglycoldiacetate PGDA

Water Solubility 8%

Water in PGDA 4%

MPC at 8% starting at 23° C

- Dipropyleneglycolmonoethyletheracetate DPMA

Water Solubility 5%

Water in DPMA 8%

MPC at 5% starting at 42° C

- Butylglycolacetate

Water Solubility 1.5%

Water in Butylglycolacetate 5%

MPC at 1.5% starting at 30° C

- Butyldiglycolacetate

Water Solubility 6.5%

Water in Butyldiglycolacetate 10%

MPC at 6.5% starting at 35° C

Alcohols

- Cyclohexanol

Water Solubility 3.7%

Water in Cyclohexanol 7%

MPC at 3.7% starting at 35° C

- Hexylalcohol

Water Solubility 0.6%

5 Water in Hexylalcohol 0%

MPC at 10% starting at 35° C

-2-Ethyl-1-hexanol

Water Solubility 0.1%

10 Water in 2-Ethyl-1-hexanol 0%

MPC at 0.1% starting at 22° C